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MEMORANDUM REPORT ARBRL-MR-03358

FUNCTIONING CHARACTERISTICS OF THE BUSHMASTER GUN HEI PROJECTILE

Jack Williams

June 1984

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
BALLISTIC RESEARCH LABORATORY
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Some experimental data have been generated to investigate the functioning characteristics of the fuzed high-explosive projectile associated with the Bushmaster gun as it would be used in an anti-aircraft role. Twenty-four rounds were fired at thin aluminum alloy plate. The main parameters under observation are the time lapse and the distance travelled by the projectiles between projectile impact and detonation. The generated data should be helpful for any assessment of the performance of this projectile used in air defense.

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TABLE OF CONTENTS

A 1

LIST OF FIGURES

1. INTRODUCTION

The Bushmaster Air Defense System utilizes a 25mm HEI-T projectile equipped with a KZB335 fuze. This projectile and fuze were originally designed for a surface-to-surface role. This report examines the performance of this fuze when the projectile impacts on aluminum alloy plate in thicknesses simulating the skin of representative aircraft targets. The functioning characteristics of the fuze that have been monitored during the experimental work are fuze delay time after projectile impact and projectile travel distance from impact time to detonation time. In addition, damage to the aluminum alloy plates and some basic observations of the fragmentation pattern were noted for each experimental round.

The experimentation was severely limited by the number of projectiles available and the safety regulations regarding the use of a 25mm gun borrowed from a Bushmaster weapon system. The latter regulations required that the projectiles be fired at service speeds ($\sim$ 1100 mps).

The impact parameters which probably determine the fuze delay and the projectile travel (from impact time to detonation time) are the target material, target thickness, angle of obliquity of impact, projectile yaw, and the impact speed. In the actual experiment, the projectiles were fired at short range ($\sim$ 30.5 meters) from the target plates, and there was no evidence of significant yaw under these circumstances. Only one target material, 2024T-3 aluminum alloy, was utilized in the experimentation. This material is representative of the skin of aircraft targets. Thicknesses of target material up to 0.64 cm were selected for the experimental work.

2. THE BUSHMASTER PROJECTILE/FUZE

The Bushmaster Air Defense System employs a gun which fires 25mm HEI-T projectiles. These projectiles are equipped with KZB335 fuzes. The projectile/fuze package was designed originally for utilization in a surface-to-surface role.

A 25mm Bushmaster gun barrel (Figure 1) was borrowed for the experimental work. The 25mm HEI-T projectile is shown in Figure 2, along with some of its characteristics.

3. THE EXPERIMENT

The firings took place in an indoor range of the Ballistic Research Laboratory. A 25mm gun barrel was obtained from a Bushmaster weapon system to use in the experiment.

A schematic of the experimental set-up along with the instrumentation is provided in Figure 3. Lumiline screens were utilized to measure the speed of the projectile.

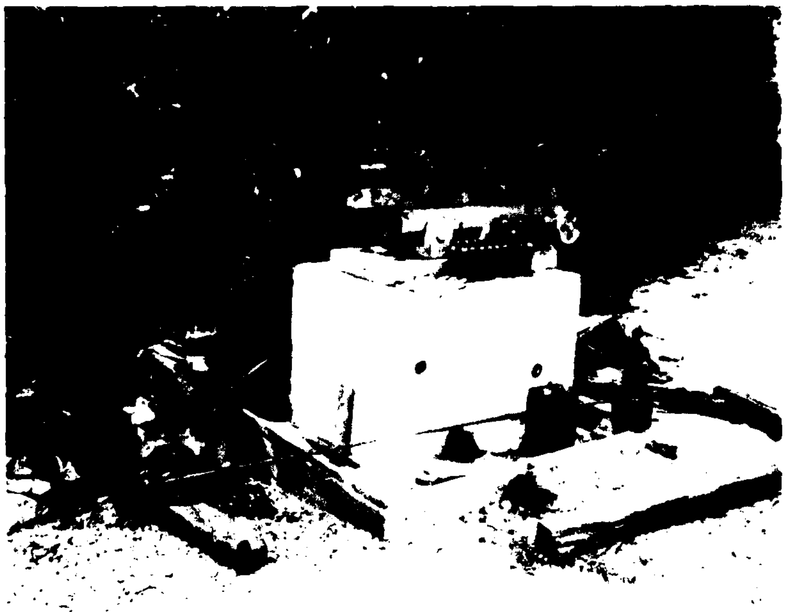
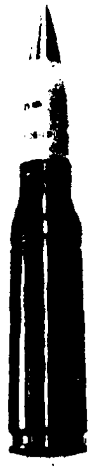


Figure 1. Bushmaster Gun Barrel



Total Projectile Length: 22.22 cm (8.75 in.)
Total Length of Uncased Projectile: 9.84 cm (3.875 in.)
Projectile Weight: 135.2 grams (2,082 grains)
Explosive Charge Weight: 27.0 grams (417 grains)

Figure 2. Bushmaster Gun Projectile

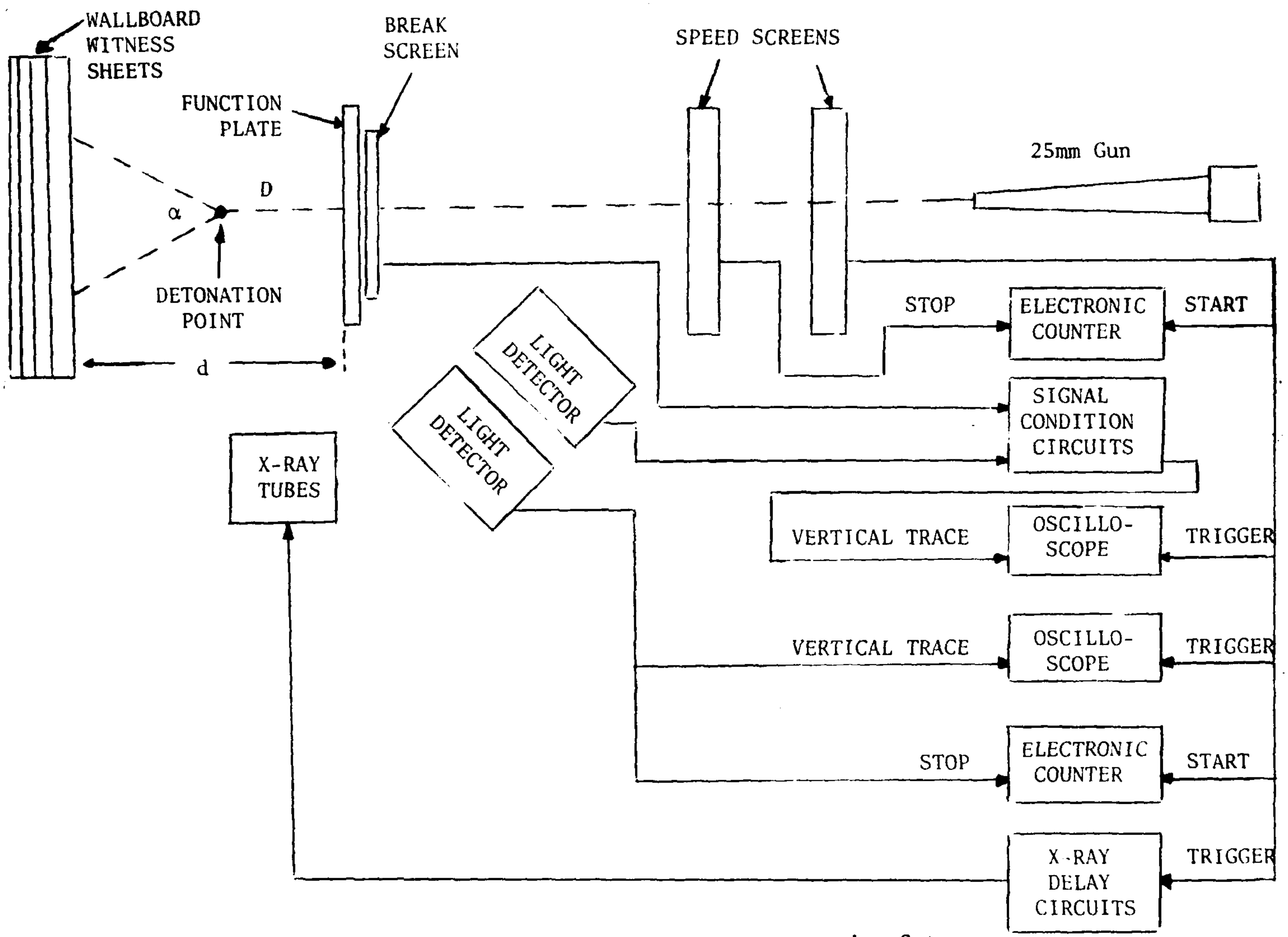


Figure 3. Schematic of Experimental and Instrumentation Set-up

Projectile functioning data were obtained from light detectors which observed the flashes corresponding to projectile impact and fuze functioning. A BRL Report* describes in detail the technique that was emulated in the current work. The skin of various aircraft targets was represented by plates of aluminum alloy (2024T-3) in thicknesses between 0.10 cm and 0.64 cm.

Fragmentation resulting both from the detonation of the projectile and the perforation of the aluminum alloy plates was monitored by virtue of banks of wallboard material placed beyond the target perpendicular to the line of fire. The leading edge of the bank of witness material was located between 0.75 and 0.90 meters behind the witness target plate.

The gun was positioned ∿ 30.5 meters away from the target plate. The projectiles arrived at the target plates at relatively constant speeds. The impact speeds varied only from 1080 to 1110 meters per second for the 24 firings.

The wallboard witness sheets provided some information of the pattern of the fragmentation that evolved from the detonation of the HEI projectile. A typical result is shown in Figure 4 for a firing against 0.10 cm aluminum alloy plate. The holes in the witness plate disclose the radius of the smallest circle about the center of the fragment distribution that would contain the entire fragmentation. Reference to Table 1 establishes that the distance from the detonation point to the bank of witness sheets is given by (d-D). Therefore, the minimum cone angle α that contains all the fragmentation from the HEI projectile is given by:

$$\alpha = 2 \arctan \; r/(d-D)$$

Table 1 reveals a relatively constant value for α under the given experimental conditions between 152 and 160 degrees as long as there is a clean separation between the projectile and the functioning plate at the time of detonation.

4. RESULTS

The experimental data are summarized in Table 1. The impact condition is given by the plate thickness, angle of obliquity, and the projectile striking speed. The last parameter varied only slightly during the experimentation -- primarily because of safety regulations and range limitations.

The principal results of the experimentation are the values of function delay time and the distance (D) of projectile travel from impact to detonation.

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* "X-ray Multi-Flash System for Measurement of Projectile Performance at the Target," C. Grabarek and L. Herr, September 1966, AD807619. BRL TN 1634.

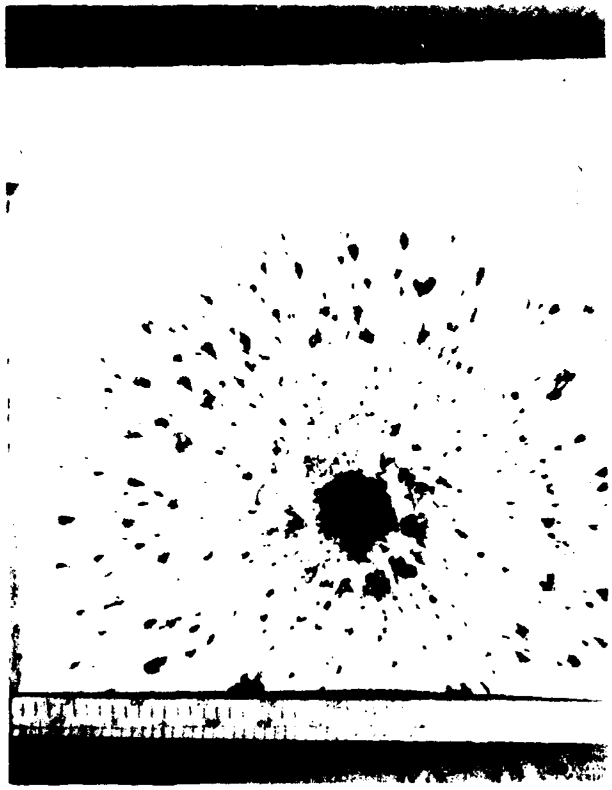

Figure 4. Fragmentation Pattern from Projectile Detonation after Impact on 0.10 cm Aluminum Alloy Target

Table 1. Experimental Data

Plate Thickness T (cm)	Obliquity Angle θ (degrees)	Striking Speed (mps)	Function Delay Time (μsec)	Distance to Detonation D (cm)	Hole Diameter (cm)	Radius of Fragment Pattern (cm)	d [a] (cm)	α [b] (degrees)
.102	0	1103	236	25.9	3.3			
.102	0	1097	250	27.4	3.3	48.3	50.8	154
.102	0	1079	215	23.1	3.8	66.0	50.8	156
.102	0	1097	256	28.2	3.3	58.4	50.8	158
.127	0	1097	192	21.1	3.3	53.3	43.2	160
.127	0	1100	155	17.0	3.6	76.2	53.3	156
.127	0	1108	161	17.8	3.3	76.2	53.3	154
.160	0	1103	135	15.0	3.3	73.7	50.8	152
.160	0	1103	123	13.5	3.3	81.3	50.8	154
.160	0	1108	129	14.2	3.3	73.7	50.8	154
.160	0	1082	138	15.0	3.3	73.7	50.8	152
.160	60	1097	73	8.1				
.160	60	1100	97	10.7				
.229	0	1108	*	*	8.6			
.229	0	1108	49	5.3	7.9			
.229	0	1103	70	7.6	7.9			
.229	0	1111	69	7.6	7.9			
.318	0	1097	67	7.4	12.2	Data Not Collected		
.318	0	1108	54	6.1	13.2			
.635	0	1095	*	*	12.7			
.635	0	1082	57	6.1	13.2			
.635	0	1103	66	7.4	13.0			
.635	0	1092	65	7.1	13.7			
.635	0	1089	61	6.6	13.0			

* Unreliable data

a Distance between function plate and witness board

b Cone angle containing all fragments from detonation of HEI projectile

Note that for the target plates for which the thickness $T > .23$ cm and for high obliquity rounds, the value of D was never much greater than ten centimeters; for all such cases, the detonation of the projectile occurred while the projectile was still passing through the plate. As a consequence, the fragmentation pattern of the HEI shell was superimposed and distorted by fragments of the witness plate. This explains why no values of α, the fragment cone angle, are given in Table 1 for such rounds.

In Figure 5, the projectile's fuze delay is plotted against $T \cdot \sec\theta$ where θ is the angle of obliquity of impact.

In Figure 6, a similar plot is made for the distance covered by the projectile between impact and detonation points.

Figure 5 indicates that a function delay of about 70 microseconds is to be expected for impact conditions where the value of $T \cdot \sec\theta$ is at least 0.20 cm. Figure 6 indicates that these 25mm projectiles travel roughly 6.35 cm from impact to detonation whenever the value for $T \cdot \sec\theta$ is at least 0.20 cm. These observations are, of course, related to a relatively constant impact speed of about 1068 mps.

5. SUMMARY

An initial investigation has been made of the functioning characteristics of the projectile associated with the Bushmaster weapon system. In 24 assorted impacts on thin aluminum alloy plate targets, the projectile perforated the target; shortly after, the fuze functioned and the projectile detonated. The experiment permitted observations to be made of the fuze delay, the projectile travel to the detonation point, hole size in the functioning plate, and the cone angle containing the fragmentation. These data should be useful in any assessment of the performance of this projectile in an air defense role.

Further experimentation should explore lower (and more realistic) impact speeds down to 450 mps and more impact conditions at high angles of obliquity. Even though this projectile and fuze may continue to operate properly for such impact conditions, the values of fuze delay and projectile travel may be significantly altered.

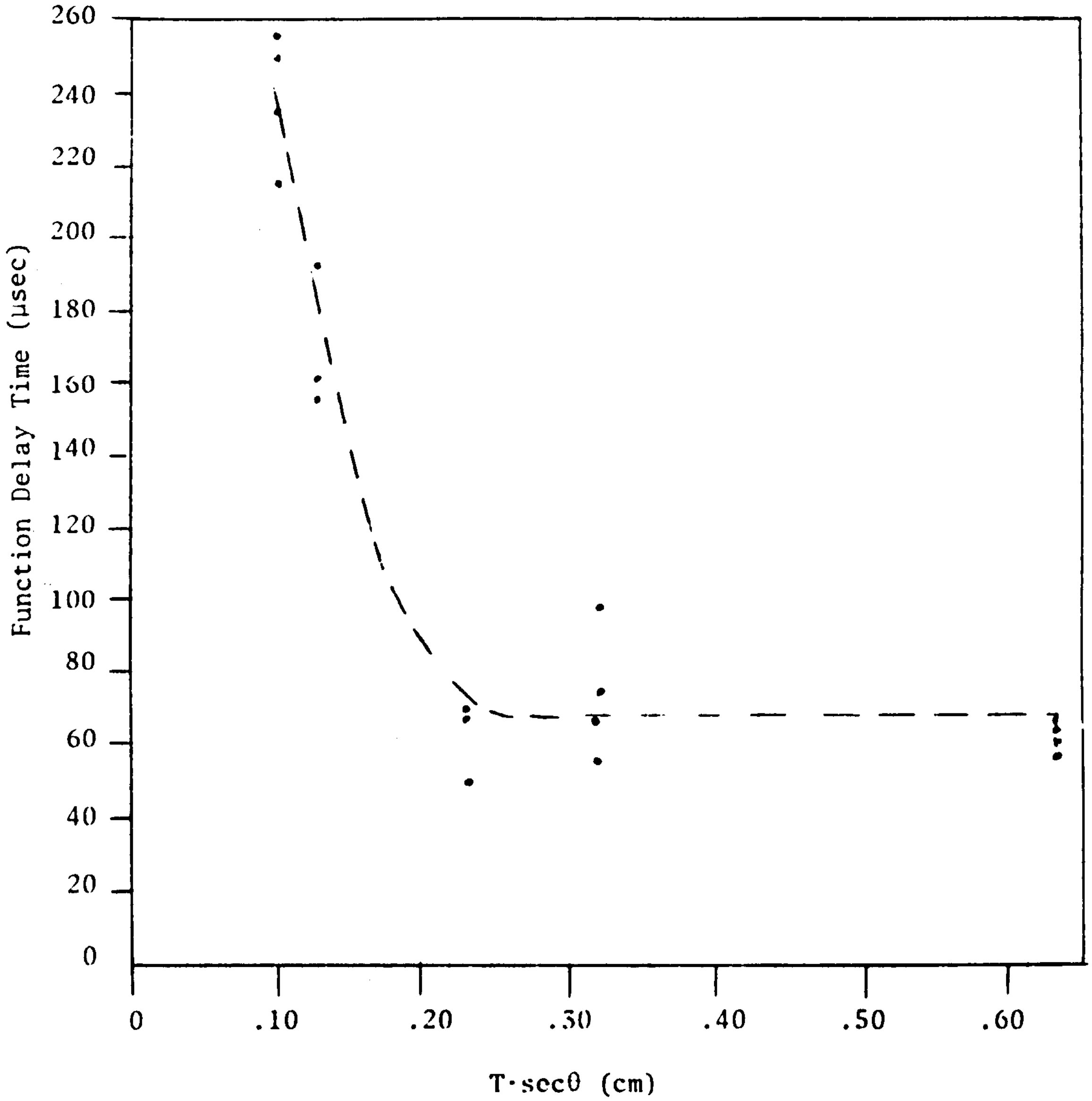

Figure 5. Function Delay Time Plotted Against Projectile Line-of-Sight Travel Through Functioning Plate

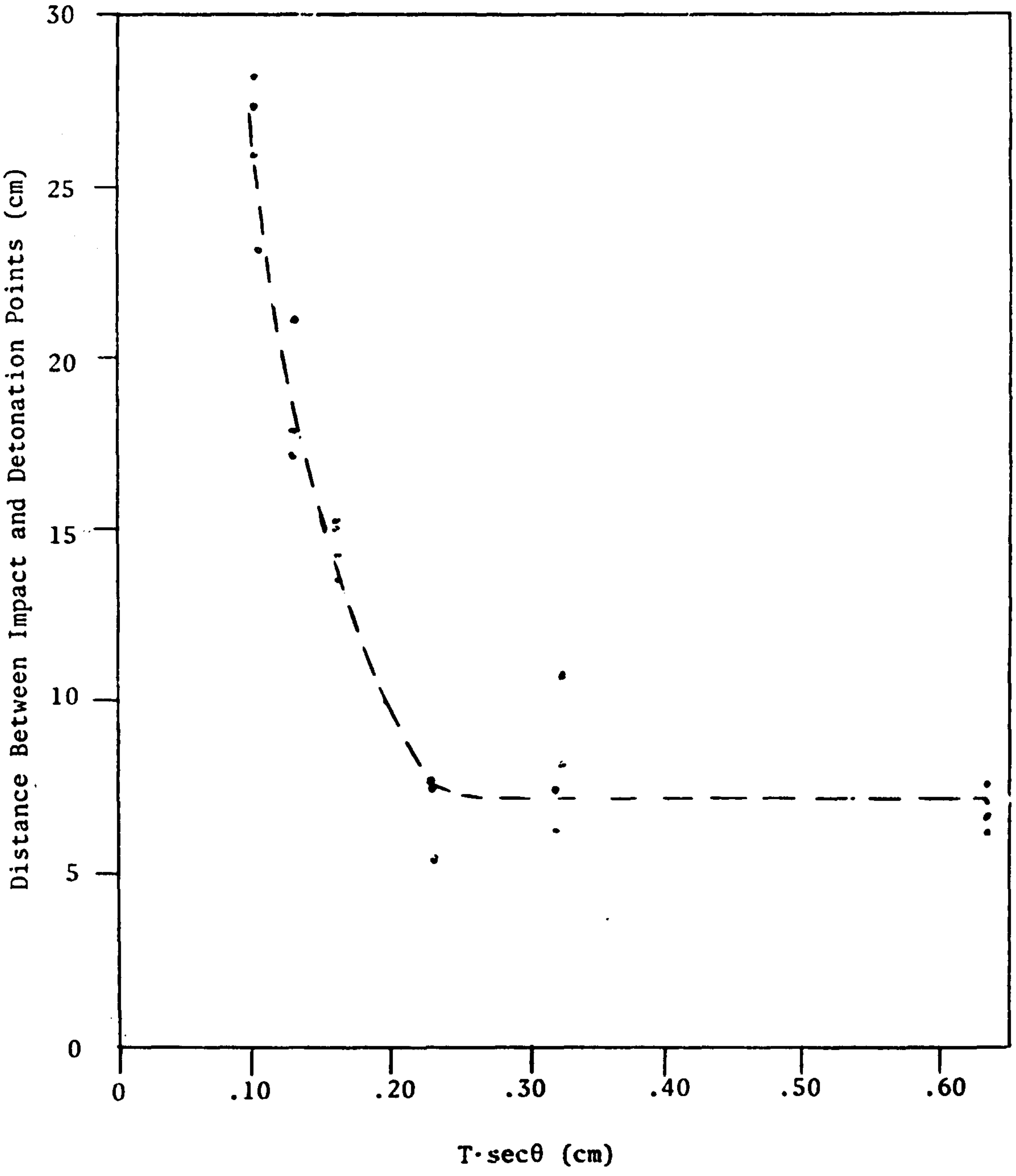

Figure 6. Distance to Detonation Plotted Against Projectile Line-of-Sight Travel Through Functioning Plate

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